LeFort I Osteotomy

Edward P. Buchanan, MD[1] Charles H. Hyman, BA[1]

[1] Division of Plastic Surgery, Michael E. DeBakey Department of Surgery, Baylor College of Medicine, Houston, Texas

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Address for correspondence Edward P. Buchanan, MD, Division of Plastic Surgery, Michael E. DeBakey Department of Surgery, Baylor College of Medicine, 6701 Fannin St, CC 610.00, Houston, TX 77030 (e-mail: ebuchana@bcm.edu).

Abstract

The LeFort I osteotomy is one of the most commonly used procedures to correct midface deformities. It allows for correction in three dimensions including advancement, retrusion, elongation, and shortening. It is indicated, often in conjunction with mandibular surgery, for class II and III malocclusion, facial asymmetry, obstructive sleep apnea, and maxillary atrophy. Before surgery, proper orthodontics and surgical planning should be undertaken to ensure adequate outcomes. Overall, the surgery is widely used due to its low complication profile and reliable long-term results.

Keywords

- LeFort I
- osteotomy
- malocclusion
- orthognathic
- distraction

The LeFort 1 osteotomy is a procedure used by maxillofacial surgeons to correct a wide range of dentofacial deformities. Because of its versatility and simplicity, it has gained popularity for a wide range of uses. The osteotomy can be performed quickly and efficiently if appropriate preoperative and intraoperative preparations are followed. The complication profile of this procedure is well established and should be understood prior to execution. Recent studies have focused on the reliability of maxillary movements as it relates to long-term stability and relapse. Overall, the LeFort 1 osteotomy is a common, predictable, and safe orthognathic intervention with reliable long-term results.

History

The LeFort I osteotomy is named after the fracture pattern originally described by Rene LeFort in 1901 that extends from the nasal septum, along the tooth apices, and through the pterygomaxillary junction. The first description of a LeFort 1 surgery was by Cheever in 1864 for the resection of a nasopharyngeal tumor.[1] The difference between the fracture pattern described by LeFort and the osteotomy relates to the status of the pterygoid plates. The LeFort 1 osteotomy spares the pterygoid plates by cutting at the pterygomaxillary junction. The procedure was first used to correct dentofacial deformities in 1921, when Herman Wassmund repositioned the maxilla after osteotomy and postoperative orthopedic traction.[2] In 1934, Axhausen mobilized the osteotomized maxilla intraoperatively to correct an open bite.[3]

This technique became more and more popular in Europe and the United States for correction of dentofacial deformities, but its stability was still in question. In 1969, Converse reported the importance of orthodontic collaboration during the planning stages for correction of dentofacial deformity with orthognathic surgery.[4] This led to a wider acceptance of the procedures and the incorporation of an orthodontist for pre- and postoperative care. Since then, many surgeons have published their experience with the LeFort 1 osteotomy for correction of dentofacial deformities as well as for access to the midface and skull base. Popularity of this surgical procedure led to the advent of the "two-jaw" surgery, LeFort I in conjunction with a bilateral sagittal split osteotomy. Prior to this, mandibular osteotomies were commonly used in isolation to correct dentofacial problems.

Indications

The LeFort I osteotomy is commonly used for the correction of malocclusion and maxillomandibular deformities. Because it allows for movement in all three planes, it is used to treat class II and III malocclusions, as well dentofacial asymmetries. Furthermore, it is commonly used to treat midface hypoplasia and vertical maxillary excess. It is important for the surgeon to incorporate the expertise of an orthodontist prior to undertaking any orthognathic procedure. The required skeletal movements must be completed in combination with dental treatment so that correct occlusion can be established. (Please refer to "Orthodontist's Role in Orthognathic Surgery"

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by Drs. John O. Wirthlin and Pradip R. Shetye in this issue regarding the orthodontic preparation of dental deformities).

Class III malocclusion is one of the most common reasons for performing a LeFort I osteotomy. It is associated with maxillary hypoplasia and is commonly found in patients with orofacial clefts, obstructive sleep apnea (OSA), and maxillary atrophy. LeFort 1 osteotomy with horizontal advancement is used for the majority of patients to correct their malocclusion. This surgery is commonly performed in the last stages of treatment for patients with cleft lip and palate. They have significant class III malocclusion as well as a narrow dental arch and palatal collapse.[5] If left untreated, the maxillary hypoplasia can lead to superior rotation of the mandible, reducing the facial height and upwardly tilting the occlusal plane. Maxillary surgery is required in up to 25% of cleft lip and palate patients.[5] Traditionally, a LeFort I osteotomy with advancement has been the standard treatment. Due to the high rates of relapse with this procedure, many have advocated segmental LeFort I osteotomy with orthodontic rapid palatal expansion.[6]

Patients with severe class II deformities due to mandibular retrognathism will often undergo LeFort 1 osteotomy and repositioning, in addition to mandibular advancement and osseous genioplasty, to achieve a more stable and aesthetic appearance.

LeFort I osteotomy is used in combination with the bilateral sagittal split osteotomy (BSSO) in correcting the secondary maxillary effects seen in asymmetrical mandibular deformities. These asymmetries are usually attributed to unilateral mandibular condylar hyperplasia during active growth of the maxilla and mandible. The asymmetric overgrowth of the ipsilateral maxilla shifts the midline and slope of the maxillary plane. LeFort I is used to realign the maxilla with the facial midline, correct the cant, and allow for advancement.

Patients suffering from vertical maxillary excess (VME) or deficiency can have the vertical height of the maxilla altered with the LeFort 1 osteotomy. Patients with VME, or "long face syndrome," will benefit from the osteotomy by decreasing the vertical position of the maxilla and the amount of gingival show. These patients often present with mandibular retrognathism, a retrusive chin, and a tendency toward class II malocclusion. Correction usually consists of two-jaw surgery and osseous genioplasty. Airway obstruction and mouth-breathing are often found associated with VME, both of which usually resolve after surgery.

LeFort I osteotomy is also used for conditions other than malocclusion, including maxillary atrophy and obstructive sleep apnea. Combined with autogenous iliac bone grafts, LeFort 1 osteotomies have been used to rehabilitate the atrophied, edentulous mandible for osteointegrated implants.[7] In severely atrophic maxillas, placement of interpositional bone grafts following the LeFort I osteotomy has shown to provide long-term stability for osteointegrated implants.[8] Obstructive sleep apnea patients who demonstrate cephalometric abnormalities consistent with airway obstruction will benefit from maxillomandibular surgery. A thorough airway evaluation should be performed to determine the level of obstruction. If the obstruction appears to be at the skeletal level, patients can undergo a bimaxillary operation for skeletal advancement. This will subsequently increase the volume of the oro- and nasopharyngeal airway and cure the patient of disease.[9]

Technique

Performing the LeFort 1 osteotomy can be one of the most enjoyable and efficient procedures in orthognathic surgery. Proper orthodontic preparation should be completed prior to any surgical intervention. This includes preoperative orthodontics for dental decompensation as well as an overall facial assessment for facial aesthetics.[10] A consistent operative sequence should be followed to expedite the procedure and eliminate unnecessary wasted time.

The patient is placed in a supine position with a shoulder roll for a neutral head position. Nasotracheal intubation is preferred in these patients so that occlusion can be checked without difficulty. The tube is usually secured with a 2.0 silk suture to either the membranous portion of the caudal septum or the anterior scalp. This allows the tube to be prepped into the surgical field and prevents it from becoming dislodged during surgery. External facial landmarks are important to establish prior to beginning the procedure so that the movement of the maxilla can be measured relative to the cranial skeleton. This is commonly done via a tattoo at the level of the medial canthus or a K-wire placed at the level of the nasofrontal junction. Once this landmark is established, preoperative measurements of the maxilla from the teeth or orthodontic brackets should be obtained on both the left and right. Local anesthesia is then injected into the gingivobuccal sulcus of the upper lip to help with hemostasis.

The incision is made with the purpose of leaving a healthy cuff of sliding gingiva. With the upper lip retracted, the amount of sliding gingival cuff left on the maxilla should be exaggerated to compensate for the amount of soft tissue stretch that occurs. The cuff will always appear shorter after it is cut. This is an important step in the operation because it will help the surgeon avoid the embarrassing complication of exposed hardware due to inadequate closure. Most surgeons will recommend a 5-mm cuff; however, in our experience adding a couple more millimeters to the incision will leave an appropriate amount of tissue for an easy, watertight closure. The incision can be made with a #15 blade or with electrocautery on a low setting.

Once through the mucosa and into the loose areolar tissue in the submucosal plane, dissection should proceed directly to bone. It is important not to leave this plane and dissect into the facial musculature. This will result in unnecessary bleeding and swelling. The incision is made from first molar to first molar, to expose both the lateral and medial buttresses of the maxilla.

When the periosteum is identified, it should be scored with electrocautery for the entire length of the incision. Subperiosteal dissection with an elevator is performed to expose the anterior surface of the maxilla. Dissection around the level of the piriform aperture should be mindful of the

nasal mucosa and lining. Particular attention should be taken to try and avoid any perforations in the nasal lining. The floor of the nose and nasal septum should be exposed back to the level of the posterior palate so that the superior surface of the palate can be visualized. Superiorly, the dissection stops at the level of the infraorbital nerves. Laterally, the dissection is carried around the lateral maxillary buttress. Care should be taken to stay in a subperiosteal plane laterally and not dissect into the soft tissue. This will prevent exposure of the buccal fat pad, which can be a nuisance to retract. The lateral dissection should end once the pterygomaxillary junction is encountered.

After the maxilla is exposed, reference points should be made on the maxilla to help achieve the preoperative plan. The aesthetic needs of the patient will help determine where the medial and lateral osteotomies are made. The osteotomy should then be marked on the maxilla with a sterile pencil or with a high-speed bur. When designing the osteotomy, care should be taken to avoid the tooth roots. Using the maxillary canine as the longest tooth root reference (26 mm), the apices of the other teeth can be avoided. At the level of the piriform, the osteotomy should always be performed below the level of the inferior turbinate to avoid damage to the nasolacrimal system.

The osteotomy is made with a reciprocating saw at the lateral maxillary buttress and directed to the ipsilateral piriform rim. The same osteotomy is performed on the contralateral side. A thin osteotome is then used to complete the posterior osteotomies of the lateral and medial maxillary buttresses. A U-shaped osteotome is used to separate the nasal septum from the maxilla. The posterior maxillary wall is then fractured with an osteotome. To avoid the internal maxillary blood vessels, care should be taken not to plunge too deep with this corticotomy.[11] During the medial maxillary buttress corticotomies, care should be taken to avoid the nasotracheal tube and an unwarranted delay in the procedure. Lastly, the pterygomaxillary junction should be separated with curved osteotomes. By placing a finger inside the mouth and feeling the hamulus, the medial extent of the osteotomy can be palpated to ensure the proper position. Once the osteotomies are completed, the downfracture is performed with digital pressure. If digital pressure does not complete the osteotomy, then a thorough interrogation of the previous osteotomies should be performed. The downfracture should be easy and should not require a large amount of force. Excessive force can cause an unfavorable fracture and complications.

Downfracturing the maxilla will allow for further dissection of the nasal floor and nasal mucosa. Any holes in the nasal lining should be closed to prevent significant bleeding and provide for nasal cavity integrity. Now that the maxilla is free, the soft tissue should be stretched to allow for greater range of motion. This can be done with mobilization forceps or with digital pressure. During the downfracture, bleeding from the osteotomies and torn mucosa should be controlled initially with packing. Any pulsatile bleeding should be controlled with bipolar electrocautery. Blood supply to the LeFort 1 segment is provided via the ascending palatine branch of the facial artery and the anterior branch of the ascending pharyngeal artery. Division of the descending palatine artery during downfracture will not result in vascular compromise of the maxilla.[12]

Once downfracture and mobilization are complete, the aesthetic needs and preoperative planning will determine the new position of the maxilla. If impaction is planned, the appropriate amount of anterior maxillary bone, septum, and vomer should be reduced to provide for a stable base and prevent nasal septal deviation. If large gaps are created for large inferior or horizontal movements, bone grafts should be considered to provide for more stable movement. These bone grafts can be taken locally from the facial bones, from the cranium via split cranial graft, or from the iliac crest.

The desired movements are made in relation to the external reference points measured preoperatively. If a surgical splint has been fashioned preoperatively, it is then used to position the maxilla by placing the patient in maxillomandibular fixation (MMF). This should be done with the mandibular condyles properly seated in their fossa, so as not to create a postoperative malocclusion.[13] Once in the proper position, the maxilla should be fixed with titanium plates and screws. For stability, 2-mm L-shaped plates, placed on each of the maxillary buttresses, are used. They are bent in an orientation that ensures the desired position of the maxilla.

The patient is released from MMF and the occlusion is checked. The maxillary midline is checked in relation to the external reference points and the central incisors are checked in relation to the mandibular incisors. Centric relation and occlusion are checked by manipulating the mandible in the relation to the position of the new maxilla. Properly seating the mandibular condyles is extremely important prior to checking the new occlusion.

After ensuring proper occlusion, the incision is closed with an absorbable suture. This is done with a 3.0 or 4.0 Vicryl suture in a horizontal mattress-type fashion to ensure a watertight closure. Some surgeons prefer an alar-cinch stitch to recreate the detached insertions of the nasalis muscle. This is done to help prevent any nasal- base widening. A V-Y advancement of the mucosa tissue can be done to help prevent a flat upper lip. This helps recreate the upper-lip pout especially after a large horizontal movement.[14]

Postoperatively, a nasogastric (NG) tube is kept in for 24 hours to help prevent nausea. The patient is placed in a heads-up position and given a handheld suction. For a one-piece LeFort 1 surgery, patients are usually not kept in MMF, but may be placed in guiding elastics to help maintain occlusion. The patient will spend one night in the hospital to help with pain and nausea. At 24 hours, the NG tube is removed and the patient is discharged if he or she is tolerating liquids, ambulating, and pain is controlled. A soft mechanical diet is continued for 4 to 6 weeks until bony union is achieved.

Segmenting the Maxilla

If the transverse dimension of the maxilla needs to be changed or if there are steps in the occlusion, a segmental LeFort 1 osteotomy can be performed.[15] The sequence of this

procedure commences after downfracturing the LeFort 1 segment. The most common segmentation is the paramedian osteotomy. This osteotomy avoids the midline to avoid the thicker bone and thinner mucosa of the maxilla. The paramedian areas of the maxilla have thicker mucosa, which is more amendable to stretching as well as thinner bone that is easier to cut. The technique involves the surgeon placing his or her finger on the palatal mucosa and using the reciprocating saw to make the osteotomy through the maxilla. Once the saw traverses the bone, the saw blade can be felt through the palatal mucosa and the saw is stopped. The alveolar ridge osteotomy is made with an osteotome after carefully releasing the attached gingiva around the interdental space that is to be divided. The tooth roots can be seen protruding through the bone and should be avoided. If the roots cannot be distinguished on clinical exam, X-rays are often helpful in identifying and protecting them from damage during maxillary segmentation.

Once the osteotomy is completed, the segments are mobilized and a prefashioned splint is used to position the maxilla in the appropriate place. The pieces of the maxilla should move and fit quite easily into the splint, otherwise the desired occlusion will not be stable. For instances in which large gaps exist between segments after fixation, autologous bone grafts are utilized. It is important to leave these patients in their occlusal splint for 4 to 6 weeks to provide the maxilla with extra support while healing.

LeFort 1 Distraction Osteogenesis

Distraction osteogenesis can be used in combination with a LeFort 1 osteotomy to correct patients with significant maxillary hypoplasia. In patients with a class III malocclusion greater than 1 cm and a normal mandibular position, LeFort 1 distraction should be considered. Many orthognathic surgeons are able to achieve stable postoperative results in patients who have a greater than 1-cm maxillomandibular difference.[16] However, there is data indicating that these movements are less stable and have higher rates of relapse when compared with patients who have been treated with distraction osteogenesis after osteotomy.[17] Cleft lip and palate patients make up the majority of the patients in this population.

If distraction osteogenesis is decided, the LeFort 1 osteotomy is performed as described above. The procedure differs once the downfracture has been completed. The same amount of mobilization of the maxilla is not required. Distraction can be achieved via an internal or an external approach. The internal distraction systems are buried underneath the mucosa and are less cumbersome after surgery. Activation of the distraction system usually begins 4 to 5 days after surgery. The device is turned until the appropriate distance is achieved. The internal devices are usually left in place for 4 to 6 weeks after the activation period has ended to allow for consolidation. The patient then returns to the operating room for removal of the internal plates. Internal distraction is limited by its lack of postoperative versatility. The vector chosen during placement of the device cannot be changed after the initial surgery. Any adjustments in the distraction vector need to be made in the operating room by adjusting the distractor itself.

The external distraction system provides for a greater degree of versatility because it is secured to the cranium and can be adjusted during the activation period. The external halo is secured to a splint that attaches to the maxilla. Activation is performed at the same time interval as the internal system and continues until the desired effect is achieved.

Complications

The LeFort I osteotomy has inherent risks and a variety of complications have been reported (►**Table 1**).[18–34] In a study of 1000 patients between 1983 and 2002, Kramer et al found that complications occurred in 6.4% of patients.[18] Patients with major anatomical irregularities, such as cleft lip and palate, were more likely to experience complications. These patients, representing 11.5% of the population, experienced nearly half the complications. Furthermore, patients with segmental LeFort 1 osteotomies or anterior movements greater than 9 mm were at a higher risk for complications. Careful preoperative planning and appropriate preoperative

Table 1 Reported complications of the LeFort I osteotomy

Reported complications	
Anatomical	Nasal septum deviation[18]
	Non-union of osteotomy gap[18]
	Malposition of maxilla[18]
	Nasolacrimal duct obstruction[19]
	Haemolacria from nasolacrimal duct perforation[20]
Septic	Abscess[18]
	Sinusitis maxillaris[18]
	Brain abscess[21]
	Actinomycosis of the maxillary sinus[22]
Ischemic	Retraction of the gingiva[18]
	Necrosis of the maxilla[18]
Vascular	Severe hemorrhage[18]
	Delayed formation of arteriovenous fistula[23]
	Pseudoaneurysm[24]
	Epistaxis[25,26]
Neurologic	Unilateral third nerve palsy[27,28]
	Total unilateral blindness[27,29]
	Occulomotor nerve palsy[30]
	Tapia syndrome[31]
	Adie pupil[32]
Otologic	Middle-ear tympanometric changes[33]
	Eustachian tube dysfunction and tinnitus[34]

consultation should be followed in these specific situations. Efforts to minimize maxillary movement (e.g., with two-jaw surgery) are recommended to reduce complications.[18]

Outcomes Data

Multiple studies have examined the stability and risk factors for relapse of the LeFort I osteotomy. Because the LeFort I is often used to correct abnormalities in multiple planes simultaneously, the rate of relapse in the literature has varied. A study of LeFort I maxillary advancement without additional surgeries or associated syndromes found that only 14% of patients had clinically significant relapse ($>$ 2 mm).[35] Similarly, in 1991 Proffit et al found a relapse rate ($>$ 2 mm) of 20%.[36] Patients treated for vertical maxillary excess had a similar relapse rate.[37,38] In the majority of cases, relapses occur during the first 6 months.[35] The biggest risk factor in predicting relapse is the distance of maxillary movement.[35]

There is a higher rate of relapse in cleft patients when compared with noncleft orthognathic patients. This has been attributed in large part to contractures of the soft tissue from previous surgeries.[39] Horizontal relapse rates after maxillary advancement have been reported as high as 37% of the overall movement, whereas vertical relapse rates are as high as 65%.[40] One meta-analysis found that the average distance of relapse was $\sim$25 to 30% of the total movement.[41] Consequently, distraction osteogenesis is being recommended as the standard treatment for patients with a history of orofacial clefts. As a result of the gradual movement and progressive bone generation, distraction osteogenesis was shown to be more stable with a relapse rate of 8.24% of the total movement.[40]

Conclusion

The LeFort I osteotomy of the maxilla is one of the core procedures in orthognathic surgery for the management of facial skeletal deformities. The surgery, often used in conjunction with the bilateral sagittal split osteotomy, is used to correct functional and cosmetic irregularities in all three planes of space and can be utilized in the treatment of a wide range of malocclusions. Traditionally, the surgery has been known for its low technical difficulty and dependable results. The LeFort I can also be used to treat obstructive sleep apnea and maxillary atrophy. An emphasis should be placed on proper presurgical orthodontics and solid presurgical planning to ensure predictable and stable results.

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